SCHOOL OF ELECTRONICS ENGINEERING

M. Tech Biomedical Engineering

(M.Tech MBE)

Curriculum

(2025 - 2026 admitted students)

VIT®

Vellore Institute of Technology

(Deemed to be University under section 3 of UGC Act, 1956)

Adaptive Curriculum for Excellence – ACE 2025-26

M.Tech Biomedical Engineering

Program Educational Objectives

1. Graduates will apply advanced knowledge of engineering, life sciences, and medical technology to design, analyze, and develop innovative biomedical systems, devices, and solutions that address healthcare challenges.

2. Engineers will demonstrate leadership, professional ethics, and effective communication skills in multidisciplinary environments, contributing responsibly to the biomedical industry, academia, and society at large.

3. Graduates will collaborate effectively with multidisciplinary teams and engage in cutting-edge research contributing to translation of scientific advancements in biomedical engineering to practical applications and continuously update their knowledge through lifelong learning.

Program Outcomes

PO1. An ability to independently carry out research /investigation and development work to solve practical problems.

PO2. An ability to write and present a substantial technical report/document.

PO3. Students should be able to demonstrate a degree of mastery over the area as per the specialization of biomedical engineering.

PO4. Apply advanced concepts of Biomedical Engineering to design and develop components and systems for healthcare applications.

PO5. Exhibit independent, and collaborative research with strategic planning, while demonstrating the professional and ethical responsibilities of the engineering profession.

PO6. Use state-of-art hardware and software tools to design experiments in medical electronic systems for the benefit of society.

Curriculum Structure

Program Credit Structure	**Credits**
University Core Courses	39
Professional Core Courses	24
Professional Elective courses	14
Open Elective Courses	03
Total Graded Credit Requirement	**80**

University Core courses (39 Credits)

S.No	Course Title	L	T	P	C
1	Technical Report Writing	1	0	4	3
2	Qualitative and Quantitative Skills Practice I	3	0	0	3
3	Qualitative and Quantitative Skills Practice II	3	0	0	3
4	Project Work	0	0	0	10
5	Internship I/ Dissertation I	0	0	0	10
6	Internship II/ Dissertation II	0	0	0	10
	Total Credits				39

Professional Core courses (24 Credits)

Professional Core Courses (24 Credits)						
S. No	**Course Code**	**Name of the Course**	**L**	**T**	**P**	**C**
1	MABML501	Sensors in Medicine and Data Acquisition	3	0	2	4
2	MABML502	Medical Imaging Techniques and Analysis	3	0	2	4
3	MABML503	Biosignal Processing and Analysis	3	0	2	4
4	MABML504	Biomedical Instrumentation and Measurements	3	0	2	4
5	MABML505	Embedded Systems for Health Care Devices	3	1	0	4
6	MABML506	Artificial Intelligence for Biomedical Engineering	3	0	2	4
		Total Credits				**24**

Professional Elective courses (14 Credits)

Professional Elective Courses (14 Credits)						
S. No	Course code	Name of the Course	L	T	P	C
1	MABML601	Biomaterials	3	0	0	3
2	MABML602	Biomechanics and Rehabilitation Engineering	3	1	0	4
3	MABML609	Lab on Chip	3	0	0	3
4	MABML603	Robotics in Healthcare	3	0	2	4
5	MABML604	Big Data Analytics in Medical Applications	3	1	0	4
6	MABML605	Physiological Control Systems	3	0	2	4
7	MABML606	Biomedical Standards in Healthcare	3	0	0	3
8	MABML608	AR/VR in Healthcare	3	0	2	4
9	MAAME615	Soft Computing Techniques	3	1	0	4
10	MABML607	Information Systems and Health Care Management	3	0	0	3

Bridge courses

S. No	Name of the Course	L	T	P	C
1	Basic Electronics and Measurements	1	0	0	1
2	Anatomy and Physiology	1	0	0	1

Course Code	Sensors in Medicine and Data Acquisition	L	T	P	C
MABML501		3	0	2	4
Pre-requisite	Human Physiology, Electronic and Electrical circuits	Syllabus Version			
		1.0			

Course Objectives

1. Introduce the fundamental principles, characteristics, and classifications of biomedical sensors used for monitoring physiological signals in clinical and healthcare applications.
2. Ability to design and implement data acquisition systems, including signal conditioning, analog-to-digital conversion.
3. Enable students to analyze, integrate, and apply sensor technologies in building reliable and safe biomedical systems, with emphasis on practical challenges like noise, calibration, and wireless communication.

Course Outcomes

1. Understand the principles and characteristics of biomedical sensors and their application in medical diagnostics and monitoring.
2. Implement data acquisition systems with signal conditioning and analog-to-digital interfaces.
3. Integrate sensors into functional biomedical systems considering real-world constraints like noise, safety, and power.
4. Interface biomedical sensors with microcontrollers using ports and communication protocols.
5. Apply acquired knowledge in lab projects or mini design tasks simulating real biomedical engineering scenarios.

Module:1	Fundamentals of Biomedical Sensors and Data Acquisition	9 hours

Introduction to biomedical sensors: classification, performance metrics; Overview of physiological parameters and sensing needs; Principles of transduction (electrical, mechanical, optical, thermal, chemical); Signal conditioning (amplification, filtering, impedance matching and AD620, INA333, ADS127L21, AMC1311); ADC/DAC basics, sampling theorem, anti-aliasing filters; Introduction to data acquisition hardware and software.

Module:2	Bio-potential and Physiological Sensors	7 hours

Bioelectrical signal sensors: ECG, EEG, EMG; Electrode types: surface, needle, dry electrodes; Electrode-skin interface, placement systems (10-20); Blood pressure sensors (invasive, non-invasive); Respiratory monitoring sensors (strain, thermistors).

Module:3	Optical, Temperature, and Chemical Sensors	9 hours

Optical sensors: principles, applications in pulse oximetry; IR sensors, photodiodes, reflectance vs. transmission mode; Temperature sensors: thermistors, thermocouples, RTDs; Chemical sensors: glucose, lactate, pH, biosensors; Enzymatic, electrochemical, ion-selective sensors.

Module:4	Motion, Imaging, and Smart Wearable Sensors	9 hours

Motion sensors: accelerometers, gyroscopes, IMUs; Biomechanical sensing: gait, fall detection, posture; Image sensors: CMOS, CCD in medical imaging; Flexible/wearable sensor platforms; Energy harvesting and wireless communication in wearable.

Module:5	Data Acquisition Systems and Applications	9 hours

DAQ systems: Microcontrollers and Embedded Systems in Biomedical Sensing; real world case study using MATLAB/LabVIEW/Arduino/ Raspberry Pi/ ESP32/ STM32/ MSP430; Interfacing methods ports, ADC, UART, SPI, I2C, PWM; Embedded wireless communication BT, Zigbee, 6LoWPAN, LoRA; IoT and remote health monitoring.

Module:6	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Books	
1	Tatsuo Tagawa, Toshiyo Tamura, P. Ake Oberg, Biomedical Sensors and Instruments, 2^{nd} Edition, April 2011, Taylor & Francis group, CRC Press.
2	Ramon Pallas-Areny, John G. Webster, Sensors and Signal Conditioning, 2^{nd} Edition, 2012, Wiley India Pvt Ltd.
Reference Books	
1.	Gabor Harsanyi, Sensors in Biomedical Applications, 2000, CRC Press.
2.	Medical Instrumentation: Application and Design, J. G. Webster, Editor, 4^{th} Edition, 2015, John Wiley & Sons, Inc., New York.
Mode of Evaluation: Quiz, Assignment, CAT and FAT	

List of Experiments (Indicative)	
Study of Sensor characteristics	**4 hours**
Signal Conditioning using ICs (Amplifiers - AD620, INA333, Filters-ADS127L21, Isolators -AMC1311)	**4 hours**
Data Acquisition and Interfacing with Lab VIEW	**8 hours**
ECG/EMG data acquisition	
Pulse oximeter prototype/ Wearable accelerometer for motion tracking/glucose sensor	**4 hours**
Design and development of biomedical sensor system using embedded platforms	**10 hours**
IoT based vital signals monitor	
Total Laboratory Hours	**30 hours**
Mode Evaluation : Continuous Assessment and Final Assessment Test.	

Recommended by Board of Studies			
Approved by Academic Council	**No.**	**Date**	

Course Code	Course Title	L	T	P	C
MABML502	**Medical Imaging Techniques and Analysis**	**3**	**0**	**2**	**4**
Pre-requisite		**Syllabus Version**			
		1.0			

Course Objectives

1. Learn the various aspects of imaging technology: X-Ray, CT, MRI, Ultrasound and Thermography.
2. Interpret biomedical images to extract pertinent physiological and clinical information.
3. Understand the application of computational tools and programming languages to medical images.

Course Outcomes

1. Apply knowledge of physics and Engineering to understand the acquisition and analysis techniques involved in different X-ray medical imaging.
2. Acquire the ability to analyze Computer Tomography techniques to extract pertinent physiological and clinical information.
3. Analyze the principle of interaction of nuclei in magnetic resonance imaging and functions of various magnet imaging components.
4. Analyze Emission, Ultrasound and thermal imaging for diagnostic applications.
5. Apply various Image processing techniques to analyze medical images using computational tools and programming languages.

Module:1	**Radiography Techniques and analysis**	**6 hours**

X-Rays, Interaction with matter, X-ray detectors, Image quality, Equipment, Clinical use- Biologic effects and safety, Calibration. Image sampling, noise and artefact , Image Enhancement, spatial methods -Histogram Processing.

Module:2	**Computed Tomography Techniques and analysis**	**12 hours**

Principles of Tomography, First to Fifth generation scanners, X-ray detectors in CT - Imaging –Single Slice, Multi Slice, Cardiac CT - Spiral CT - Image quality –Equipment, Calibration. Methods of reconstruction, Iterative, Back projection, convolution and Back-Projection, FDK algorithm, noise, artefacts. Image degradation models, smoothing spatial filters for noise removal, Sharpening Spatial filters, restoration filters, Region based segmentation, Region growing, Region splitting and merging, Morphological processing- erosion and dilation, Segmentation by morphological watersheds, K-means clustering algorithm.

Module:3	**Magnetic Resonance Imaging and Analysis**	**9 hours**

NMR, Principles of MRI, Relaxation processes and their measurements T1 and T2, Pulse sequencing and MR, MRI system- System Magnet, generation of Gradient magnetic Fields, Radio Frequency coils, Shim coils, Electronic components. Functional MRI, Diffusion imaging. Organ boundary representation, Boundary description, Fourier Descriptor, Regional Descriptors — Topological feature, Texture - Patterns and Pattern classes - Recognition based on matching, shape spaces, learning shape models, learning shape mean and modes of variation — identifying human organs and substructures.

Module:4	**Nuclear Medicine Imaging and Analysis**	**9 hours**

Radionuclides-photons and particles with matter - Data acquisition Imaging - Image quality Equipment – PET, SPECT, PET-CT, PET-MRI-clinical use- Biologic effects and safety–Calibration. PET-CT, SPECT registration, Similarity models, deformation models, energy functions, optimization algorithms - anatomical atlas generation, co-registration, motion correction.

Module:5	Ultrasound , Thermography Imaging and Analysis		7 hours
Physics of acoustic waves-Generation and detection of ultrasound - Doppler imaging- Image quality - Equipment - Heat Exchange and Infrared radiation -Detectors– Image Acquisition – Image display – clinical use- Biologic effects and safety, Calibration. Computer aided diagnosis using CNN, segmentation using adversarial networks, Lesion detection using machine learning.			
Module:6	**Contemporary Issues**		**2 hours**
		Total Lecture hours:	**45 hours**

Text Books	
1	Paul Suetens, Fundamentals of Medical Imaging, 2017, 3rd Edition, Cambridge University Press, Cambridge, New York.
2	S. Kevin Zhou, Daniel Rueckert, Gabor Fichtinger, Handbook of Medical Image Computing and Computer Assisted Intervention, 2020, Academic Press.
Reference Books	
1.	Gopal B. Saha, Physics and Radiobiology of Nuclear Medicine, 2013, 4th Edition, Springer-Verlag, New York
2.	Russell K. Hobbie, Bradley J. Roth, Intermediate Physics for Medicine and Biology, 2015, 5th Edition, Springer International Publishing, Switzerland.
3.	Gonzalez and Woods, Digital Image Processing, 4th edition, 2018, Pearson.
4.	Kurt Ammer, Francis Ring, The Thermal Human Body: A Practical Guide to Thermal Imaging”, 2019, Jenny Stanford Publishing Pvt. Ltd, Singapore.
Mode of Evaluation: Quiz, Assignment, Design Project, CAT and FAT	

List of Experiments (Indicative)	
Using spatial filters enhance the given noisy medical image. Compare the performance of various filters	**6 hours**
Design suitable filters in frequency domain for noise removal from the given medical image	**6 hours**
Using region growing algorithm segment the gray matter, white matter and CSF from the given MR brain image.	**6 hours**
Extract the features of interest from the given CT abdomen images and Classify.	**6 hours**
Read the given PET and CT image and register them.	**6 hours**
Total Laboratory Hours	**30 hours**
Mode Evaluation : Continuous Assessment and Final Assessment Test.	

Recommended by Board of Studies			
Approved by Academic Council	**No.**	**Date**	

Course Code	Course Title	L	T	P	C
MABML503	Biosignal Processing and Analysis	3	0	2	4
Pre-requisite		Syllabus Version			
		1.0			

Course Objectives

1. The students will get a fundamental concept of biosignals, their physiological origins, and the characteristics of commonly encountered biomedical signals.
2. To equip students with essential signal processing techniques in time, frequency, and time-frequency domains for effective analysis of bio signals.
3. To develop practical skills in processing real-world biomedical data through signal acquisition, preprocessing, denoising, and interpretation using modern tools and algorithms

Course Outcomes

1. Describe the origin and physiological relevance of biomedical signals, demonstrating foundational knowledge of their characteristics and clinical importance.
2. Analyze biomedical signals in time and frequency domain to assess their characteristics and diagnostic value in identifying different disease conditions.
3. Identify common artifacts and noise in biomedical signal acquisition and apply appropriate filtering techniques to enhance classification and prediction.
4. Describe the basic architecture of the TMS320 DSP processor and evaluate its implementation and applications in real-time signal processing.
5. Appreciate the operation of processors and its special applications.

Module:1	Introduction to Bio signals	7 hours

Introduction to signals - Electrical activities of the Cell, Action Potential, Nature of Biomedical Signals, Examples of Bio signals - Statistical and information theoretical analysis.

Module:2	Time-Frequency Domain Analysis	9 hours

Fundamental Concepts of Filtering, Linear shift-invariant filters, transform domain analysis of bio signals, Fourier spectrum of bio signals, short-time Fourier transform and spectrogram - DCT and its applications - Wavelet transform and time frequency analysis - Hilbert transform and its applications - Empirical mode decomposition and empirical wavelet transform – correlation analysis and power spectral estimation.

Module:3	Digital Filters	9 hours

Types of artefacts and noise - Time domain filters, Synchronized averaging, MA filters, Derivative-based operators to remove low- frequency artifacts, Various specifications of a filter, frequency domain filters, Removal of high-frequency noise: Butterworth lowpass filters, Removal of low-frequency noise: Butterworth high pass filters, Removal of periodic artifacts: Notch and comb filters, optimal filtering, adaptive filters - Signal decomposition-based filtering.

Module:4	Feature Extraction Techniques and Detection of Events	9 hours

Signal segmentation - Envelop extraction and analysis, temporal, spectral, statistical, information theoretic and cross spectral features - Waveform complexity, Detection of Events with ECG and EEG waveforms, Detection of Events and Waves, Derivative-based methods for QRS detection, The Pan–Tompkins algorithm for QRS detection, Correlation Analysis of EEG Rhythms, Detection of EEG rhythms, Template matching for EEG spike-and-wave detection, Detection of EEG rhythms related to seizure, Homomorphic filtering: Extraction of vocal tract response.

Module:5	Digital Signal Processors	9 hours
General purpose DSP processors, architecture, hardware configuration, software development tools - Implementation considerations, fixed point DSP processors, floating point DSP processors. TMS320 Architecture - Functional units - Pipelining-Registers - Linear and Circular addressing – Types of instructions - Sample Programs - Real Time Implementation on DSP processors - Factors to be considered for optimized implementation based on processor architecture: Implementation of simple Real Time Digital Filters, FFT using DSP - Overview of Black Fin Processors.		
Module:6	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Books

1	R M Rangayyan, Biomedical Signal Analysis: A case Based Approach, 2002, IEEE Press, John Wiley & Sons. Inc.
2	Kayvan Najarian and Robert Splinter, Biomedical Signal and Image Processing, 2^{nd} Edition, 2005, CRC Press.

Reference Books

1.	Willis J. Tompkins, Biomedical Digital Signal Processing, 2004, EEE, PHI.
2.	D C Reddy, Biomedical Signal Processing: Principles and Techniques, 2005, Tata McGraw-Hill Publishing Co. Ltd.

Mode of Evaluation: Quiz, Assignment, Design Project, CAT and FAT

List of Experiments (Indicative)	
Representation of different biosignals	**5 hours**
Design of tuned filters	**5 hours**
Time domain analysis of ECG	**4 hours**
Time domain analysis of EEG	**4 hours**
Frequency domain analysis of ECG	**4 hours**
Frequency domain analysis of EEG	**4 hours**
Analysis of other biosignals	**4 hours**
Total Laboratory Hours	**30 hours**

Mode Evaluation : Continuous Assessment and Final Assessment Test.

Recommended by Board of Studies			
Approved by Academic Council	**No.**	**Date**	

Course Code	Course Title	L	T	P	C
MABML504	**Biomedical Instrumentation and Measurements**	**3**	**0**	**2**	**4**
Pre-requisite		**Syllabus Version**			
		1.0			

Course Objectives

1. Elucidate the fundamental principles of bio-potential electrodes, their role in physiological signal measurement and to analyze the architecture of the medical equipment.
2. Provide comprehensive knowledge on the measurement of non-electrical physiological parameters and relevant biochemical signals.
3. Describe the operational modes and functionalities of various diagnostic and therapeutic biomedical equipment.

Course Outcomes

1. Explain the origin, propagation, and characteristics of biopotentials and bio signals, and analyze the functional blocks of biomedical instrumentation systems.
2. Demonstrate the working principles and applications of various patient monitoring systems and telemedicine technologies.
3. Analyze operation of analytical, diagnostic instruments, therapeutic and life-support devices, ensuring their clinical significance and engineering implementation.
4. Assess safety standards, regulations, and potential hazards in biomedical equipment, integrating emerging technologies such as AI in biomedical instrumentation.
5. Demonstrate practical skills in operating, testing, and calibrating biomedical instruments and patient monitoring systems, ensuring adherence to safety and performance standards.

Module:1	**Introduction to Biomedical Instruments**	**8 hours**

Biopotential origin and propagation – Generalized architecture of Biomedical Instruments - Recorders and Recording problems - measurement with two electrodes - General considerations for recording system, writing systems. Bio signals characteristics – frequency and amplitude ranges-errors in bio-signal measurements.

Module:2	**Patient Monitoring Systems**	**10 hours**

(Working Principle and Application) Electrocardiograph (ECG), Electroencephalograph (EEG), Electromyography (EMG), ERG and EOG, Basic Principle and Mechanism of Cardiac Monitor, Heart Rate monitor, Pulse Rate monitor, Bedside patient monitor, Blood pressure Measurements, Audiometers and hearing aids, Single Channel Telemetry Systems and telemedicine.

Module:3	**Analytical Instruments and Radiation Detectors**	**8 hours**

Principle of operation and Application: Blood Gas Analyzers (pH & PCO2 Measurement), Blood Cell Counter, Colorimeter, Spectrophotometer, Oximeter. Physics of radioactivity, ionization chambers, pulse height analyzer, Gamma camera.

Module:4	**Therapeutic Equipment and Therapy Devices**	**9 hours**

Cardiac pacemakers, Defibrillators, Hemodialysis machine, Ventilators, Humidifiers, Nebulizers, Anesthesia Machines, Surgical Diathermy, Shortwave diathermy, Microwave diathermy, Ultrasound diathermy.

Module:5	**Patient Safety medical equipment**	**8 hours**

Electrical Shock Hazards, Leakage current, safety codes for electro medical equipment, Electric safety analyzer, Testing of biomedical equipment. Overview of standards and errors in Biomedical Instrumentation- AI in Biomedical Instrumentation

Module:6	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Books

1	R S. Khandpur, Handbook of Biomedical Instrumentation, 2014, 3rd Edition, Tata Mc Graw Hill, New Delhi.
2	John G. Webster, Medical Instrumentation Application and Design, 2015, 4th Edition, John Wiley and sons, New Jersey.

Reference Books

1.	Carr –Brown, Introduction to Biomedical Equipment Technology, 2011, 1st Edition, Pearson, New York.
2.	Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer, Biomedical Instrumentation and Measurements, 3rd Edition, 2015, Prentice Hall India Learning Pvt. Ltd.

Mode of Evaluation: Quiz, Assignment, Design Project, CAT and FAT

List of Experiments (Indicative)

Design and realization of Instrumentation amplifier	**2 hours**
Design and realization of ECG amplifier	**4 hours**
Analysis of EEG signal using simulated waveforms	**2 hours**
Measurement of Blood Pressure	**4 hours**
Acquisition of Operating skills with surgical diathermy, Ventilator and Haemodialysis machine	**6 hours**
Design and development of Audiometer Instrumentation	**4 hours**
Evaluation of hearing acuity using audiometer	**4 hours**
Heart sound measurement using Phonocardiography	**2 hours**
Design of cardiac pacemaker in simulation platform	**2 hours**
Total Laboratory Hours	**30 hours**

Mode of Evaluation: Continuous Assessment and Final Assessment Test

Recommended by Board of Studies			
Approved by Academic Council	**No.**	**Date**	

Course Code	Course Title	L	T	P	C
MABML505	**Embedded Systems for Health Care Devices**	**3**	**1**	**0**	**4**
Pre-requisite		**Syllabus Version**			
		1.0			

Course Objectives

1. Understand the architecture and design principles of embedded systems in healthcare applications.
2. Develop embedded software and hardware solutions for medical devices, adhering to industry standards.
3. Apply AI and IoT techniques for real-time health monitoring and diagnostics.

Course Outcomes

1. Comprehend the role of embedded systems in medical devices, for healthcare applications.
2. Compare different microcontroller architectures and memory types for optimizing power efficient devices.
3. Interface sensors with embedded systems using communication protocols
4. Implement RTOS concepts for real-time medical embedded systems.
5. Design AI-driven healthcare solutions for smart medical devices.

Module:1	**Introduction to Embedded Healthcare Systems**	**12 hours**

Overview of embedded systems in medical devices, selection of microcontrollers, medical vs consumer grade embedded systems. Embedded Design life cycle, Layers of Embedded Systems. Embedded System modelling [FSM], UML as Design tool, UML notation, Requirement Analysis and Use case Modelling for healthcare applications, UI-UX.
Case study & Discussion: Designing a Patient Monitoring System UI using UML notation. Discuss the importance of user interactive systems.

Module:2	**Embedded Processors for Medical Devices**	**12 hours**

Microcontroller architectures (RISC,CISC), Embedded Memory, Strategic selection of processor and memory, Low-power microcontrollers and processors, optimized for power efficiency, wearable, portable devices and IoMT.
Case study & Discussion: Designing a Low-Power ECG Wearable Using MSP430 Microcontroller. Addressing concerns in processor selection for medical devices.

Module:3	**Enabling Technologies for Healthcare Systems**	**12 hours**

USB, PCI, PCI Express, UART, SPI, I2C, CAN, Bluetooth Low Energy (BLE), WiFi, WPAN, LoRaWAN, NB-IoT, Sensor interfacing ECG, EEG, SpO2, temperature.
Case study & Discussion: Developing a Wireless Blood Pressure Monitoring System Using BLE. Discuss challenges in sensors and communication integration.

Module:4	**RTOS for Embedded systems**	**12 hours**

Real-time constraints & RTOS, Tasks, Process, Threads, Multiprocessing, Multitasking, Task scheduling, Communication, Synchronisation. Inter-process Communication (Shared Memory, Mailbox, Message Queue), Inter Task Synchronization (Semaphore, Mutex), Introduction to TinyOS.
Case study & Discussion: Implementing Real-Time ECG Data Processing Using FreeRTOS. Discuss the challenges in handling synchronization in embedded healthcare systems.

Module:5	Intelligent Healthcare with Embedded Systems	10 hours
Evolution of smart medical devices, smartwatches, patches, pacemakers, neurostimulators, smart beds, infusion pumps, Single board Computing: TinyML Fundamentals, AI-driven anomaly detection: Sepsis prediction, Fall detection, Sleep Apnea detection, Digital Twins for patient-specific modelling. Regulatory Standards, FDA, ISO 13485. Case study & Discussion: Sepsis Prediction Using TinyML on an Edge AI Device. Future of intelligent healthcare with embedded systems.		
Module:6	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**60 hours**

Text Books

1	Marilyn Wolf, Computers as Components: Principles of Embedded Computing System Design, The Morgan Kaufmann Series in Computer Architecture and Design, 5th Edition, 2022, ISBN: 9780323851282.
2	Raj Kamal, Embedded systems, Tata McGraw- Hill, 4th edition, 2020, ISBN: 9780070494701.

Reference Books

1.	Maryam Hussein Mansi, Zahraa Wahab Abbas, Hussein Ali Dhiab and Ali Qahtan Adnan, Embedded Systems in Medical Devices: Design and Implementation, 1st Edition, 2025, ISBN: 9789393992321.
2.	Manisha Guduri, Chinmay Chakraborty, Martin Margala, Smart Devices for Medical 4.0 Technologies Hardcover, CRC Press, 1st Edition, 2025, ISBN: 9781003603610.
3.	Colin Walls, Embedded RTOS Design: Insights and Implementation, Newnes Publisher, 1st Edition, 2020, ISBN: 9780128228517.
4.	Dawoud Shenouda Dawoud and Peter Dawoud, Serial Communication Protocols and Standards RS232/485, UART/USART, SPI, USB, INSTEON, Wi-Fi and WiMAX, River Publishers, 1st Edition, 2025, ISBN: 9788770221542.
5.	Karthik C et. al., Machine Learning for Healthcare Systems Foundations and applications, River Publishers, 1st Edition, 2025, ISBN: 9788770228114.

Mode of Evaluation: CAT, Assignment, Quiz, Case Study, FAT.

Recommended by Board of Studies			
Approved by Academic Council	**No.**	**Date**	

Course Code	Course Title	L	T	P	C
MABML506	Artificial Intelligence for Biomedical Engineering	3	0	2	4
Pre-requisite	Nil	Syllabus Version			
		1.0			

Course Objectives

1. Introduce the foundations of AI in healthcare and biomedicine
2. Apply machine learning algorithms to solve biomedical problems
3. Analyze deep learning architectures for biomedical applications

Course Outcomes

1. Differentiate the forms of learning, classification, regression and clustering tasks and their evaluation metrics.
2. Apply fundamental machine learning techniques to biomedical data, including data preprocessing, model selection, evaluation metrics.
3. Analyze the core concepts and principles of different deep learning architectures.
4. Integrate AI techniques effectively in healthcare problems.
5. Apply machine learning and deep learning tools to biomedical tasks.

Module:1	Introduction to AI in Biomedical Engineering	8 hours

Relevance of AI in biomedical applications, Differences between AI, ML, and DL, Data types and sources in biomedicine, Data collection and preprocessing, forms of learning: Supervised, semi-supervised, unsupervised and reinforcement learning. Classification, regression and clustering, Loss functions, optimization, bias-variance trade off- cross validation, regularization, and evaluation metrics.

Module:2	Machine Learning Fundamentals	8 hours

Bayes decision theory, Support Vector Machine, K-Nearest Neighbour, Ensemble Learning, Decision trees and Random Forests, k-means clustering, Principle Component Analysis.

Module:3	Neural Networks and Deep Learning	10 hours

Perceptron, Deep neural network architectures, back-propagation, regularization, CNN for medical image analysis-Convolution, pooling, and fully connected layers, RNN for time series biomedical data, Generative models: Auto-encoders, Generative Adversarial Neural network.

Module:4	AI training Challenges and Emerging Architectures	9 hours

Challenges in AI training: limited and imbalanced data- data augmentation, hyper parameter tuning, interpretability and explainability, transfer learning and fine tuning, attention and transformers, diffusion models for medical image synthesis.

Module:5	AI for Healthcare Applications	8 hours

AI in medical image analysis, disease prediction and early diagnosis, personalized medicine, clinical decision support system, wearables and health monitoring, Natural language processing in healthcare, Predictive analytics for patient outcome.

Module:6	Contemporary Issues	2 hours
	Total Lecture hours:	**45 hours**

Text Books	
1.	Russell, Stuart, and Peter Norvig, Artificial Intelligence: A Modern Approach, 4th Edition, 2020, Boston, Pearson.
2.	Jorge Garza Ulloa, Applied Biomedical Engineering Using Artificial Intelligence and Cognitive Models, 1st Edition, 2021, Academic Press.
Reference Books	
1.	Bishop and Christopher M. Pattern Recognition and Machine Learning, 2016, New York, Springer Reprint.
2.	Ian Goodfellow, Yoshua Bengio, Aaron Courville, and Yoshua Bengio, Deep learning, 2016, Cambridge, MIT press.
3.	Maria Deprez & Emma C. Robinson, Machine Learning for Biomedical Applications: With Scikit-Learn and PyTorch, 2022, London, Academic Press.
4.	Maria Deprez & Emma C. Robinson, Artificial Intelligence in Healthcare, 2020, London Academic Press.
Mode of Evaluation: Quiz, Assignment, Design Project, CAT and FAT	

List of Experiments (Indicative)	
Introduction to AI Programming	**2 hours**
ECG Signal Classification for Arrhythmia Detection - Use ML algorithms (e.g., SVM, Random Forest) to classify arrhythmias from ECG features.	**4 hours**
Cardiovascular Disease Prediction with Ensemble Methods -Apply ensemble models (e.g., AdaBoost, Gradient Boosting) to improve diagnostic accuracy.	**4 hours**
Medical Image Classification Using CNN -Train a Convolutional Neural Network to detect pneumonia or tumors in X-ray or MRI images.	**4 hours**
Anomaly Detection in Patient Monitoring Data - Use unsupervised methods to detect outliers in ICU or wearable sensor data.	**4 hours**
Seizure Detection from EEG Signals Using LSTM - Build an LSTM network to classify EEG time-series data for epilepsy prediction.	**4 hours**
U-Net for Medical Image Segmentation- Segment anatomical structures (e.g., tumors, organs).	**4 hours**
Explainable Deep Learning in Healthcare - Use SHAP or Grad-CAM to interpret deep learning predictions.	**4 hours**
Total Laboratory Hours	**30 hours**
Mode Evaluation : Continuous Assessment and Final Assessment Test.	

Recommended by Board of Studies			
Approved by Academic Council	**No.**	**Date**	

Course Code	Course Title	L	T	P	C
MABML601	Biomaterials	3	0	0	3
Pre-requisite		Syllabus Version			
		1.0			

Course Objectives

1. Acquaint student with concepts of biomaterials, various materials and its role in the health care industry.
2. Explore various material syntheses, characterization techniques and their functional ability in the health care.
3. Acquire knowledge on advanced material and their fabrication technologies.

Course Outcomes

1. Analyse the recent advancement in biomaterials and its application.
2. Acquire knowledge of biomaterials synthesis and physiochemical characterization technique.
3. Establish the concept of advanced fabrication technology and methods of additive manufacturing involved in the development of biomaterials.
4. Acquire knowledge on various biocompatibility assessment of biomaterials and analyze the concept of translation and societal impact of biomaterials.

Module:1	Recent Advancements in Biomaterials for healthcare applications	10 hours

Historical development and future directions (removal - replacement - regeneration), Classification: Polymers, ceramics, metals, composites, and bioactive materials, Key clinical needs in drug delivery, and tissue repair. Structure–Property Relationships in Biomaterials. Recent advancements: Smart biomaterials, 3D/4D biomaterials, Bioinspired materials, and nanostructured biomaterials.

Module:2	Characterization of Biomaterials	12 hours

Surface Modification and Functionalization, Structural and Morphological Characterization, X-ray diffraction, Scanning Electron Microscopy, Transmission Electron Microscopy, Atomic Force Microscopy, Chemical and Compositional Analysis, Fourier Transform Infrared Spectroscopy, X-ray Photoelectron Spectroscopy, Raman Spectroscopy, Mechanical and Thermal Characterization, Mechanical Testing, Nanoindentation and AFM-based force spectroscopy, Thermal Analysis: Differential Scanning Calorimetry, Thermogravimetric Analysis, Surface and Interfacial Properties, Contact Angle Goniometry, Zeta Potential.

Module:3	Additive manufacturing for Biomaterials	7 hours

3D/4D Printing, Micro and Nano fabrication, Processing of Ceramics, Patient specific implant fabrication using additive manufacturing, 3D powder printing, 3D plotting, Post processing, Organ-on-Chip and Microfluidic Biomaterials.

Module:4	Biocompatibility Assessment of Biomaterials	7 hours

Biocompatibility: definition, principles, and types, Cytotoxicity, genotoxicity, immunogenicity, In vitro testing: cell culture, MTT/XTT, Live-Dead assays, In vivo testing: animal models, histological analysis, Degradation mechanisms: hydrolytic, enzymatic, oxidative, Hemocompatibility and thrombogenicity, Sterility and endotoxin testing, Clinical evaluation, ISO 10993 standards.

Module:5	Translation, Commercialization, and Societal Impact of Biomaterials	7 hours

Clinical and Regulatory Translation, From bench to bedside: translational pipeline, Regulatory bodies (FDA, EMA, PMDA) and ISO standards, Preclinical & clinical trial design for biomaterials. Commercialization and Industry Practices, Intellectual Property (IP) and patenting strategies, Start-

up ecosystems and venture creation in biomaterials, Technology transfer and academic–industry collaborations, Case studies of failed biomaterial products (e.g., metal-on-metal hip implants).		
Module:6	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Books	
1	Avi Domb, Boaz Mizrahi, Shady Farah, Biomaterials and biopolymers, 2023,1st Edition Springer Nature, Science.
2	Ahmed, S. and Tomer, A. eds., Bionano composites in Tissue Engineering and Regenerative Medicine. 2021, Woodhead Publishing.
Reference Books	
1.	Wang, Z.L., Characterization of Nanophase Materials, 2001, Wiley-VCH, Weinheim, Germany.
2.	Pradeep, T., Nano The Essentials, 2007, Tata Mc Graw Hill, New Delhi.
3.	Ramakrishna, S., Ramalingam, M., Kumar, T.S. and Soboyejo, W.O., 2016. Biomaterials: a nano approach. CRC press.
Mode of Evaluation: Quiz, Assignment, Design Project, CAT and FAT	

Recommended by Board of Studies			
Approved by Academic Council	**No.**	**Date**	

Course Code	Course Title	L	T	P	C
MABML602	**Biomechanics and Rehabilitation Engineering**	**3**	**1**	**0**	**4**
Pre-requisite		**Syllabus Version**			
		1.0			

Course Objectives

1. Assimilate the concepts of mechanics in human body
2. Perceive the concepts of motor and sensory rehabilitation
3. Identify the parameters and constraints pertaining to the designing of the orthoses and prostheses.

Course Outcomes

1. Interpret the concepts of human mechanics.
2. Realize the structure and function of joints and muscles.
3. Analyze the normal and pathological, posture and gait to develop assistive devices for their optimization.
4. Recognize the concept of motor and sensory rehabilitation.
5. Apply the knowledge for developing orthotics, prosthetics and devices for rehabilitation.

Module	Title	Hours
Module:1	**Mechanics in Human Body**	**12 hours**
Kinematics, kinetics, force systems, resultant forces, Newton's laws governing the movements, levers in the body, muscle contraction, roles of skeletal muscles.		
Module:2	**Joints and Muscles**	**12 hours**
Bones, Joints - types, structure and function, Muscle structure, mechanical equivalent, Analysis of human joints - Shoulder, elbow, spine, hip, knee and ankle.		
Module:3	**Human Ergonomics**	**8 hours**
Posture & Gait: Normal, Ideal, Abnormal; Factors influencing posture and gait: Age, gender, occupation, sports, hobbies.		
Module:4	**Concepts of Rehabilitation**	**16 hours**
Terms - Impairment, disability, handicap, Disability Act, Motor rehabilitation & Sensory rehabilitation - concepts, Complications, cause, management of stroke, hemiplegia, paraplegia, monoplegia, quadriplegia, cerebral palsy, Parkinson's disease, Alzheimer's disease, bed riddance, leprosy, foot drop paralysis, speech disorders, autism spectral disorder, visual and hearing disabilities.		
Module:5	**Orthotics and Prosthetics**	**10 hours**
Difference between orthosis and prosthesis, sensors and materials selection, operational considerations, wearable devices, robotic approach and automation.		
Module:6	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**60 hours**

Text Books

1	Pamela K Levangie and Cynthia C Norkins, Joint Structure and Function: A Comprehensive Analysis, 2019, 6th Edition, F. A. Davis Company, USA.
2	Susan J Hall; Basic Biomechanics, 2021, 9th Edition, Mc Graw Hill, India

Reference Books			
1.	R S Bridger, Introduction to Human Factors and Ergonomics, 2018, 4th Edition, CRS Press Taylor and Francis Group, USA.		
2.	Fulk G D and Chui K K, O'Sullivan and Schmitz's Physical Rehabilitation, 2024, 8th Edition, F. A. Davis Company, USA.		
Mode of Evaluation: Quiz, Assignment, Project, CAT and FAT			
Recommended by Board of Studies			
Approved by Academic Council	**No.**	**Date**	

Course Code	Course Title	L	T	P	C
MABML609	**Lab-on-chip**	**3**	**0**	**0**	**3**
Pre-requisite	**Nil**	**Syllabus version**			
		1.0			

Course Objectives:

1. Educate on the rudiments of various miniaturization, methods and tools to create microfluidic architectures and discuss various existing microfluidic devices.
2. Introduce and discuss the fundamental physics of micro scale fluids and its hydrodynamics.
3. Discuss and identify the usage of microfluidics in various lab-on-chip and biosensing applications along with their latest trends for low-cost diagnostic applications.

Course Outcomes:

1. Apply the concept of miniaturization, methods and tools to create microfluidic structures.
2. Analyze the fundamental principles of flow in microfluidic channels.
3. Acquaint with various components of a lab-on-chip based microfluidics and biosensors for various applications.
4. Apprehend the advanced developments in lab-on-chip based microfluidic applications for modelling low-cost diagnostic devices.

Module:1	Microfabrication Technology	9 hours

Historical background of Microfabrication: MEMS and Microfluidics - Applications in healthcare industry, Microsystems and Miniaturization. Materials for Microfabrication – Silicon, Polymers; Thin film coating- PVD, CVD; Photolithography, Lift-off technique, Etching, Bulk and Surface Micro machining, soft lithography – Micro moulding & Replica moulding, Fabrication of microfluidic channels; Introduction to NEMS and Nanofluidics.

Module:2	Fundamentals for Microscale Flow	10 hours

Introduction to Scaling Laws, Scaling in Geometry, Scaling in Fluid Mechanics/ Microfluidics; Fluids and nonfluids, properties of fluids, classification of fluids, Newtonian and Non-Newtonian fluids, pressure driven flow, Navier Strokes equation, Flow pattern and Reynolds number, Laminar flow; Introduction to surface, surface charge, surface energy, surface tension, capillary flow, diffusion, contact angle and wetting. Electrokinetic phenomena -Electro osmosis, Electrophoresis, Dielectrophoresis, Electric Double Layer (EDL), Debye length, Coupling species transport and Fluid mechanics, Microchannel resistance.

Module:3	Microfluidics Lab-on-Chip	9 hours

Introduction to Lab-on-a-Chip platforms, Components of LoC Systems- Microvalves, Micropumps- mechanical (membrane type) and non-mechanical (electrical-electro-osmosis, electrophoretic, DEP, EHD), Micromixers – Active and Passive, T-Mixer and Y-Mixer, Zigzag and Curved Micromixers; Fluid movement: mixing, heating, cooling; Applications – Pressure switch, Pattern creation, Electrowetting on Dielectrics (EWOD), Centrifugal Microfluidics, Microfluidic Reactors.

Module:4	Lab-on-Chip Biosensors	7 hours

Electrodes Fabrication, Electrochemical Detection Techniques- Amperometric, Potentiometric, Conductimetric, Impedimetric; Detection Methods – Electrical, Optical, Thermal; Enzyme immobilization techniques, Applications- Enzymatic-Based LOC Biosensors, Antibodies-Based LOC-Biosensors, Cell-Based LOC-Biosensors.		
Module:5	**Advanced Topics in Lab-on-Chip**	**8 hours**
Organ-on-chip, Lab-on-Chip for single-cell analysis, Microfluidic systems for drug discovery and delivery, 3D Microchannels; Low-Cost POC Diagnostics -Paper/Fabric/ Thread-based microfluidics – properties, current status, challenges, detection techniques; Droplet/Digital Microfluidics; Microfabrication of vasculature, Materials for 3D Microfluidic vasculature; Mathematical modelling of microchannels, Multiphysics coupling of fluid, thermal, electrical fields.		
Module:6	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Jaime Castillo-León, Winnie E. Svendsen (eds.), Lab-on-a-Chip Devices and Micro-Total Analysis Systems - A Practical Guide, 2015, Springer International Publishing.
2.	Tai-Ran Hsu, MEMS & Microsystem, Design and manufacture, 2017, 1st Edition, McGraw Hill, New York.
3.	Marc J. Madou, Fundamentals of Microfabrication: The Science of Miniaturization, 2002, 2nd Edition, CRC Press, Florida, USA.

Reference Books

1.	Gary S. May and Simon Sze, Fundamentals of semiconductor fabrication, 2010, 1st Edition John Wiley & Sons, New Jersey, USA.
2.	Francis E. H. Tay, Microfluidics and Biomems application, 2013, 1st Edition, Springer, Berlin.
3.	Albert Folch, Introduction to Biomems, 2016, 1st Edition, CRC Press, Florida.
4.	Edwin Oosterbroek and Albert van den Berg, Lab-on-a-Chip: Miniaturized Systems for (Bio) Chemical Analysis and Synthesis, 2011, 1st Edition, Elsevier Science, Amsterdam, Netherlands.

Mode of Evaluation: Quiz, Assignment, CAT, FAT

Recommended by Board of Studies	DD-MM-YYYY		
Approved by Academic Council	No. xx	Date	DD-MM-YYYY

Course code	Course title	L	T	P	C
MABML603	**Robotics in Healthcare**	**3**	**0**	**2**	**4**
Pre-requisite		**Syllabus version**			
		1.0			

Course Objectives:

1. Introduce the fundamental concepts and structure of robotic systems.
2. Develop an understanding of medical robot design and motion analysis.
3. Explore the applications and impact of robotics in healthcare.

Course Outcomes:

1. Describe the basic concepts, structure, and classification of robotic systems.
2. Explain spatial relationships and orientation techniques used in robotic systems.
3. Apply kinematic methods to analyze the motion of robotic manipulators.
4. Evaluate the role of robots in surgical and non-surgical healthcare applications
5. Demonstrate the functioning and application of robotic systems relevant to healthcare interventions.

Module:1	**Introduction to Robotics**	**6 hours**
History of Robotics, Components and Structure of Robots, Degrees of Freedom and Workspace, Classification of Robots, Common Kinematic Arrangements, Robotic Systems, Accuracy and Repeatability, Wrists and End-Effectors.		
Module:2	**Robot Position and Orientation**	**10 hours**
Describing spatial position and orientation, Relative position and orientation, Linkages, Three-joint Robot, Standardizing Kinematic Analysis, Computing Joint Angles, Quaternions		
Module:3	**Robot Kinematics**	**12 hours**
Three-Joint Robot, Six-Joint Robot, Inverse Solution for the Seven-Joint DLR-Kuka Robot, Eight-Joint Robot, C-Arm, Forward Analysis, Inverse Analysis, Applications, Center-of-Arc Kinematics, Surgical Microscopes, Kinematics and Dexterity		
Module:4	**Surgical Robotics**	**10 hours**
Applications of Surgical Robotics, Radiosurgery, Orthopedic Surgery, Urologic Surgery and Robotic Imaging, Cardiac Surgery, Neurosurgery, Control Modes		
Module:5	**Robotics for non-Surgical Interventions**	**5 hours**
Rehabilitation, Neuroprosthetics, Rehabilitation for Limbs, Brain-Machine Interfaces, Steerable Needles, Personal care robots, Person carrier robots, Wheeled passenger carriers, Legged person carriers, Lower limb exoskeletons, Mobile assistance robots.		
Module:6	**Contemporary issues:**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1.	Mark W. Spong, Seth Hutchinson, M. Vidyasagar, Robot Modeling and Control, 2020, 2nd Edition, Wiley Publisher.
2.	Achim Schweikard, Floris Ernst, Medical Robotics, 2015, 1st Edition, Springer Cham.

Reference Books	
1.	Paula Gomes, Medical Robotics: Minimally Invasive Surgery, 2012, 1st Edition, Woodhead Publisher, UK.
2.	John J. Craig, Introduction to Robotics, Mechanics and Control, 2010, 3rd Edition, Pearson Education.
3.	Jaydev P Desai, The Encyclopedia of Medical Robotics: Vol 1&2, World Scientific, 2018.
4.	JocelyneTroccaz, Medical Robotics, 2013, 1st Edition, Wiley, USA.
5.	Eduard Fosch-Villaronga, Robots, Healthcare, and the Law: Regulating automation in personal care, 2020, Routledge Press, London.
Mode of Evaluation: Quiz, Assignment, Design Project, CAT , FAT	

List of Experiments (Indicative)	
Robot Structure and Workspace	**2 hours**
Accuracy & Repeatability	**4 hours**
3D Positioning	**4 hours**
Forward Kinematics	**4 hours**
Inverse Kinematics	**2 hours**
Dexterity Test	**2 hours**
Surgical Path Tracing	**4 hours**
Co-manipulation Task	**2 hours**
EMG-Triggered Movement	**4 hours**
IMU/Flex-Based Assistive Arm	**2 hours**
Total Laboratory Hours	**30 hours**
Mode of Evaluation: Continuous Assessment and Final Assessment Test	

Recommended by Board of Studies	DD-MM-YYYY		
Approved by Academic Council	No. xx	Date	DD-MM-YYYY

Course Code	Course Title	L	T	P	C
MABML604	Big Data Analytics in Medical Applications	3	1	0	4
Pre-requisite		Syllabus Version			
		1.0			

Course Objectives

1. The students will get a fundamental concept of small/big and structured/ unstructured data
2. Equip students with essential features of data visualization, simulation and modelling approaches for medical data
3. Develop web and text mining tools and its applications in health care data.

Course Outcomes

1. Create and explore the sources of healthcare data
2. Integrate mining, modelling and analytics technique for health care data
3. Demonstrate the use of prediction, analytics methods in temporal and data for supporting decision making.
4. Articulate the genome data and big volumes of data in health care data analytics.
5. Describe the use of analytical algorithms in health care data analytics tools.

Module:1	Healthcare Data Sources and Basic Analytics	10 hours

Introduction: Healthcare Data Sources and Basic Analytics, Advanced Data Analytics for Healthcare, Applications and Practical Systems for Healthcare. Healthcare Data Sources and Basic Analytics: EHR, Components of HER, Coding Systems, Benefits of EHR. Barriers to Adopting EHR, Challenges of Using EHR Data, Phenotyping Algorithms.

Module:2	Biomedical Image, Signal and NLP Analysis	12 hours

Imaging modalities: Object Detection, Image Segmentation, Image Registration, Feature Extraction. Types of biomedical signals: ECG Signal Analysis, Denoising of Signals, Multivariate Biomedical Signal Analysis, Cross-Correlation Analysis. Natural Language Processing and Data Mining for Clinical Text: Natural Language Processing, Core NLP Components, Mining Information from Clinical Text, Clinical Text Corpora and Evaluation.

Module:3	Advanced data analytics	12 hours

Clinical prediction model, Basic Statistical Prediction Models, Alternative Clinical Prediction Models, Survival Models, valuation and Validation. Temporal Data Mining for Healthcare Data Association Analysis, Temporal Pattern Mining, Other Temporal Modeling Method. Visual Analytics for Healthcare, Introduction to Visual Analytics and Medical Data Visualization. Social Media Analytics for Healthcare, Social Media Analysis for Detection and Tracking of Infectious Disease Outbreak, Social Media Analysis for Public Health Research, Analysis of Social Media Use in Healthcare.

Module:4	Genomic Data Analysis for Personalized Medicine	12 hours

Genomic Data Generation, Methods and Standards for Genomic Data, Types of Computational Genomics Studies towards Personalized Medicine, Genetic and Genomic Studies to the Bedside of Personalized Medicine. predictive Models for Integrating Clinical and Genomic Data, Different Types of Integration, Different Goals of Integrative Studies, Validation. Applications and Practical Systems for Healthcare: Mathematical methods of ECG data analysis, Fraud Detection in Healthcare, Knowledge Discovery-Based Solutions for Identifying.

Module:5	Clinical Decision Support Systems and Data Analytics for Pharmaceutical Discoveries	12 hours
Various Types of CDSS, Decision Support during Care Provider Order Entry, Human-Intensive Tech, Challenges of CDSS, legal and Ethical Issues, Chemical and Biological Data, spontaneous Reporting Systems (SRSs), Patient-Generated Data on the internet. Information Retrieval for Healthcare, knowledge-Based Information in Healthcare and Biomedicine, Content of Knowledge-Based Information Resources, Indexing, Retrieval, Evaluation.		
Module:6	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**60 hours**

Text Books	
1	Chandan K. Reddy and Charu C Aggarwal, Healthcare data analytics, 2015, Taylor & Francis.
2	Hui Yang and Eva K. Lee, Healthcare Analytics: From Data to Knowledge to Healthcare Improvement, 2016, Wiley.
Reference Books	
1.	Anand Rajaraman and Jeffrey David Ullman, Mining of Massive Datasets, 2012, CUP.
2.	Bill Franks, Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics, 2012, John Wiley and sons.

Mode of Evaluation: Quiz, Assignment, Design Project, CAT and FAT

Recommended by Board of Studies			
Approved by Academic Council	**No.**	**Date**	

Course Code	Course Title	L	T	P	C
MABML605	**Physiological Control Systems**	**3**	**0**	**2**	**4**
Pre-requisite	**Nil**	**Syllabus Version**			
		1.0			

Course Objectives

1. Introduce the fundamental principles of control theory as applied to physiological systems, including feedback, stability, and system dynamics.
2. Highlight the role of analytical and computational methods in analyzing the dynamic response and performance of physiological control systems across time and frequency domains.
3. Provide knowledge and skills to analyze the stability the physiological control systems and to estimate the system parameters.

Course Outcomes

1. Model physiological processes using mathematical techniques.
2. Evaluate the transient response characteristics of linear physiological systems using first- and second-order models.
3. Interpret the frequency response and stability of linear physiological control systems.
4. Apply basic system identification methods to estimate the parameters of physiological models
5. Use MATLAB and SIMULINK software to analyze and simulate models of physiological control systems.

Module:1	**Mathematical modeling of physiological processes**	**8 hours**

Physiological control systems: simple examples – Difference between engineering and physiological control systems-Models with combinations of systems elements – Linear models of physiological systems – Laplace transform and transfer functions.

Module:2	**Time Domain Analysis of Linear Control Systems**	**8 hours**

Linearized Respiratory Mechanics: open loop vs closed loop - Open loop and closed loop
Transient Response: First Order Model, Second Order Model - Descriptors of Impulse and Step Responses - Open loop versus closed loop Dynamics - Model of Neuromuscular Reflex motion.

Module:3	**Frequency Domain Analysis of Linear Control Systems**	**8 hours**

Steady state responses to sinusoidal inputs - Graphical representation of frequency response - Frequency response of a model of circulatory control - Frequency response of Glucose Insulin regulation-Design of lag, Lead and Lag-Lead compensator, Design of PID controllers.

Module:4	**Stability Analysis**	**9 hours**

Stability and Transient Response - Root Locus Plots - Routh - Hurwitz Stability Criterion - Nyquist Criterion for Stability - Relative Stability - Effect of addition of poles and zeros - Stability Analysis of the Pupillary light Reflex - Model of Cheyne-Stokes Breathing.

Module:5	**Identification of Physiological Control Systems**	**10 hours**

Basic problems in physiological system analysis-Non parametric and parametric identification methods: Least square and recursive least square techniques-Problems in parameter estimation: Identifiability and input design- Identification of closed loop systems.

Module:6	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Books	
1	Michael C.K. Khoo, Physiological Control Systems: Analysis, Simulation and Estimation, 2018, 2nd Edition, Prentice Hall of India.
2	Joseph DiStefano, Dynamic Biosystem Modeling & Simulation Methodology: Integrated & Accessible, 2023, 3rd Edition, Biomodeling Educator.
Reference Books	
1.	J. Fernández de Cañete , C. Galindo , J. Barbancho , A. Luque, Automatic Control Systems in Biomedical Engineering, 2018, 1st Edition, Springer Nature.
2.	Stanley Reisman, Arthur B. Ritter, Vikki Hazelwood, Bozena B. Michniak, Antonio Valdevit, Alfred N. Ascione, Biomedical Engineering Principles, 2018, 1st Edition, CRC Press.
Mode of Evaluation: Quiz, Assignment, Design Project, CAT and FAT	

List of Experiments (Indicative)	
Develop a mathematical model and analyse the response of muscle stretch reflex mechanism for an impulse input.	**2 hours**
Develop the simplified model of cardiovascular system and measure the rise time, peak overshoot, settling time and steady state error for the nominal values of L, C and R and compare with the response of diseased person.	**4 hours**
Identify the physiological system from the time response analysis for the known input and output conditions.	**4 hours**
Respiratory System Dynamics and Feedback Control - Open and closed loop modeling - Block diagram implementation in Simulink - Analysis of stability and settling time	**4 hours**
Frequency Response Analysis of a Neuromuscular System - Bode plot generation - Gain and phase margin analysis - Discuss implications for tremor or control lag in muscle systems	**4 hours**
Frequency response analysis and designing of lag/lead compensator for improving the phase margin, gain margin and bandwidth of the light pupil reflex model. Estimate the rage of K for stability.	**4 hours**
Design of controllers (P,PI, PID) for improving time domain specifications of lung mechanics	**4 hours**
Closed-Loop Control of Blood Glucose Levels (Glucose-Insulin System) - Model glucose-insulin dynamics using differential equations - Implement a PID controller to maintain glucose at setpoint - Tune Kp, Ki, Kd and evaluate system performance	**4 hours**
Total Laboratory Hours	**30 hours**
Mode Evaluation : Continuous Assessment and Final Assessment Test.	

Recommended by Board of Studies			
Approved by Academic Council	**No.**	**Date**	

Course Code	Course Title	L	T	P	C
MABML606	Biomedical Standards in Healthcare	3	0	0	3
Pre-requisite		Syllabus Version			
		1.0			

Course Objectives

1. Introduce the need for standardization and regulatory frameworks in the design and development of biomedical devices and healthcare technologies.
2. Describe the biomedical standards such as ISO, IEC, HL7, DICOM, and FDA regulations.
3. Apply standards for ensuring safety, interoperability, and compliance in biomedical systems and patient data management.

Course Outcomes

1. Demonstrate the need for standardization and different standards used for biomedical applications.
2. Apply standards relevant to medical device design, testing, and certification processes.
3. Analyze safety, performance, and interoperability issues in healthcare technology based on established biomedical standards.
4. Interpret compliance requirements and documentation procedures for regulatory approvals in various global markets.

Module:1	Medical devices — ISO standards	9 hours

Introduction to Medical Standards, Importance and Necessity of Standards, Consequences of Non-Standardization, Types of Standards, Introduction to Regulatory Bodies and Organizations- Medical devices — Quality management systems — Requirements for regulatory purposes-ISO13485, Application of risk management to medical devices, ISO14971, ISO223-1, ISO11607, Biological evaluation of medical devices, ISO10993-1.

Module:2	Electronic Patient Record and Standards	9 hours

Electronic Patient Record, Medical data formats, Medical Standards, HL7, DICOM, LOINC, PACS, Medical Standards for Vocabulary, ICD 10, DRG, MeSH, UMLS, SNOMED, Healthcare Standards - JCAHO, HIPAA, Clinical investigation of medical devices for human subjects — Good clinical practice-ISO14155.

Module:3	National standards	9 hours

National Quality Assurance Standards; Indian Public Health Standards Indian Standards (NABH, NABL); ISI, ISO 9000, EMS 14000, ISO 27000, ISO 15189; International (JCI, CAP, NIAHOSM, AABB, LEED), CDSCO, BIS standards.

Module:4	Medical equipment – IEC standards	9 hours

Medical electrical equipment — IEC 60601-2-52:2009 Part 2-52: basic safety and essential performance of medical beds, IEC/TR 60601-4-1:2017, Guidance and interpretation — Medical electrical equipment - IEC 60601-2-31:2020, interoperability.

Module:5	Cyber security in health care	9 hours

Healthcare cybersecurity, Unveiling cybersecurity risks in healthcare, Healthcare cybersecurity best practices, Building a cybersecurity culture in healthcare- case studies.

Module:6	Contemporary Issues	2 hours
	Total Lecture hours:	45 hours

Text Books	
1.	Sudip Paul, Biomedical Engineering and its Applications in Healthcare, 2016, Springer.
2.	Edward H. Shortliffe, James J. Cimino, Biomedical Informatics, 2014, Springer.
Reference Books	
1.	Jocelyn Jennings and Jay Y. Vaishnav, Fundamentals of Medical Device Regulations: A Global Perspective, 2025, Published by RAPS, ISBN: 978-1-947493-94-0.
2.	National Quality Assurance Standards and Assessors Guidebooks.
3.	Manuals of IPHS, ISO, NABH, NABL, JCI .
Mode of Evaluation: Quiz, Assignment, CAT and FAT	

Recommended by Board of Studies			
Approved by Academic Council	**No.**	**Date**	

Course Code	Course Title	L	T	P	C
MABML608	**AR/VR in Healthcare**	**3**	**0**	**2**	**4**
Pre-requisite		**Syllabus Version**			
		1.0			

Course Objectives

1. Learn the various aspects of immersive technology: AR and VR.
2. Implement immersive technology to patient care and therapy in healthcare.
3. Understand the application of computational tools and programming languages in healthcare.

Course Outcomes

1. Apply knowledge of immersive technology to understand AR and VR in healthcare.
2. Acquire the ability to understand and analyze the AR/VR hardware and software for healthcare applications.
3. Apply the AR/VR technologies to various medical training and education.
4. Apply the AR/VR technologies to patient care and therapy.
5. Apply various immersive techniques for healthcare training, education, patient therapy using computational tools and programming languages

Module:1	Introduction to Augmented and Virtual Reality Technologies	9 hours

Introduction to Augmented Reality (AR) and Virtual Reality (VR): Definitions, History, and Evolution, Types of AR/VR: Fully immersive, semi-immersive, Key components of AR/VR systems: Displays (HMDs, projectors, screens), Tracking systems (optical, inertial, magnetic), Input devices (controllers, haptic interfaces), Rendering engines, Understanding human perception in AR/VR: Visual, auditory, haptic, vestibular senses, , AR/VR technologies in healthcare, Ethical considerations in AR/VR development and deployment.

Module:2	AR/VR Development Tools for Healthcare Applications	9 hours

AR/VR hardware relevant to healthcare: Head-mounted displays (HoloLens, Magic Leap, Oculus Quest), Projection-based AR, Surgical displays, Haptic feedback devices, Software platforms and development tools for healthcare AR/VR applications: Unity, Unreal Engine, specialized medical imaging software integration, Data integration and interoperability with Electronic Health Records (EHRs) and medical imaging systems (DICOM), Security and privacy considerations for patient data in AR/VR environments, Ergonomics and safety guidelines for using AR/VR equipment in clinical settings.

Module:3	Applications of AR/VR in Medical Training and Education	9 hours

VR for surgical simulation and procedural training: Benefits, challenges, and examples (Laparoscopic surgery, Endoscopy), AR for anatomy education and visualization: Interactive 3D models, cadaveric dissection enhancement, VR for medical skills training: Patient communication, empathy development, emergency response scenarios, AR/VR for medical device training and education for healthcare professionals and patients.

Module:4	AR/VR for Patient Care and Therapy	9 hours

AR for guiding medical procedures: Image-guided surgery, vein visualization, intraoperative navigation, VR for pain management and distraction therapy: Chronic pain, burn victims, dental procedures, VR for rehabilitation and physical therapy: Motor skill recovery, balance training, virtual environments for exercise, AR/VR for mental health applications: Exposure therapy for anxiety disorders, PTSD treatment, social skills training, VR for patient education and adherence: Understanding medical conditions, medication management, Telehealth and remote patient monitoring using AR/VR.

Module:5	Future Trends and Challenges in AR/VR for Healthcare	9 hours
Advancements in AR/VR hardware: Higher resolution displays, improved tracking, realistic haptics, Developments in software and AI integration: Intelligent virtual agents, personalized experiences, data analytics, The role of cloud computing in enabling advanced AR/VR healthcare applications, Regulatory landscape and standardization for medical AR/VR devices and software, Accessibility and inclusivity considerations in designing healthcare AR/VR solutions.		
Module:6	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Books

1	William R. Sherman and Alan B. Craig, Understanding Virtual Reality: Interface, Application, and Design, Second Edition, 2018, The Morgan Kaufmann publisher.
2	Dieter Schmalstieg and Tobias Hollerer, Augmented Reality: Principles and Practice, First edition, 2016, Pearson International Publishing.

Reference Books

1.	Steve Aukstakalnis, Practical Augmented Reality: A Guide to the Technologies, Applications, and Human Factors, First edition, 2016, Addison-Wesley Professional.
2.	Georgios Tsoulfas, Medical and Surgical Education - Past, Present and Future g, 2017, Intechopen Publishing.

Mode of Evaluation: Quiz, Assignment, CAT and FAT

List of Experiments (Indicative)

Using AR for anatomy education and visualization: Interactive 3D models, cadaveric dissection enhancement	**6 hours**
Using VR for medical skills training: Patient communication, empathy development, emergency response scenarios	**6 hours**
Using AR/VR for medical device training and education	**6 hours**
Using VR for rehabilitation and physical therapy	**6 hours**
Using AR/VR for patient education and adherence.	**6 hours**
Total Laboratory Hours	**30 hours**

Mode Evaluation : Continuous Assessment and Final Assessment Test.

Recommended by Board of Studies			
Approved by Academic Council	**No.**	**Date**	

Course Code	Course Title	L	T	P	C
MABML607	**Information Systems and Healthcare Management**	**3**	**0**	**0**	**3**
Pre-requisite		**Syllabus Version**			
		1.0			

Course Objectives

1. Provide a comprehensive understanding of healthcare management and its resources
2. Familiar with different types of information systems and decision-support systems in healthcare
3. Acquire knowledge and insights about digital transformation of Data in Healthcare.

Course Outcomes

1. Acquire the importance of health information systems and identify their barriers.
2. Differentiate between data, information, and knowledge, and explore the applications of various databases.
3. Demonstrate the importance of health records and different management concepts applied in healthcare.
4. Acquire the significance of Artificial Intelligence in healthcare and its role in the digital transformation of healthcare data.

Module:1	**Health Information System**	**7 hours**

System Components, Networked Communities, Host Management, User Management-Application-Level Services, Network Level Services, Principles of Security, Security Implications,
Key players in health information technology, Organizations involved with HIT-Barriers to hit adoption-Health informatics resources.

Module:2	**Healthcare Data, Information and Analytics**	**9 hours**

Definitions And Concepts-Converting Data to Information to Knowledge-Clinical Data Warehouses (CDWS) - Terminology of Analytics-Challenges to Data Analytics-Role of Informaticians in Analytics-Research and Application of Analytics.

Module:3	**Hospital Management – HIS and EHR**	**9 hours**

Need for HMIS, Capabilities & Development of HMIS, functional area, modules forming HMIS, Maintenance and development of HMIS-Ideal Features and functionality of CPR, Development tools for CPR. Need For Electronic Health Records -Electronic Health Record Key Components-Computerized Physician Order Entry (CPOE)-Clinical Decision Support Systems (CDSS) - Electronic Prescribing-Electronic Health record adoption and Challenges.

Module:4	**Operations Management in Healthcare**	**9 hours**

Supply chain and capacity management in Healthcare, Lean management, process improvement, service excellence and business process re-engineering, quality measurement and benchmarking in healthcare, Project management in healthcare.

Module:5	**AI and Digital Transformation in Healthcare**	**9 hours**

Introduction to Artificial Intelligence in Healthcare, Telemedicine and Digital Patient Experience, Digital Transformation Strategy, Implementing artificial intelligence in Healthcare, Demand forecasting in Healthcare, Predictive Analysis and Six-sigma in healthcare.

Module:6	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Books			
1	Robert e. Hoyt, Health Informatics, Practical Guide for Healthcare and Information Technology, 7th Edition, 2018, Electronic edition.		
2	Sharon B. Buchbinder, Nancy H. Shanks, M Bobbie J. Kite, Introduction to Healthcare Management, 4th Edition, 2019, Jones & Barlett Learning.		
Reference Books			
1.	Govind Madhav, Santhosh Kumar, Handbook of Hospital Administration, 2018, Elsevier.		
2.	Edward H. Shortliffe , James J. Cimino, Biomedical Informatics: Computer Applications in Healthcare and Biomedicine (Health Informatics), 4th Edition, 2014, Springer, NY.		
Mode of Evaluation: Quiz, Assignment, CAT and FAT			
Recommended by Board of Studies			
Approved by Academic Council	**No.**	**Date**	

<table>
<tr><td>Course Code</td><td colspan="2">Course Title</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>XXXXXXXX</td><td colspan="2">Anatomy and Physiology</td><td>1</td><td>0</td><td>0</td><td>1</td></tr>
<tr><td>Pre-requisite</td><td colspan="2"></td><td colspan="4">Syllabus Version</td></tr>
<tr><td></td><td colspan="2"></td><td colspan="4">1.0</td></tr>
<tr><td colspan="7">Course Objectives</td></tr>
<tr><td colspan="7">1. Familiarize learners with anatomical and medical terminologies
2. Analyze the requirements for the functioning of cardiorespiratory and excretory systems
3. Assimilate the coordination of skeletal, muscular, neurological systems and special sense organs</td></tr>
<tr><td colspan="7">Course Outcomes</td></tr>
<tr><td colspan="7">1. To realize anatomical and medical terminologies, organization of tissues and organ systems.
2. To demonstrate the structure and functioning of cardiorespiratory system.
3. To illustrate the role of excretory system.
4. To evaluate the structure, coordinated functioning of skeletal and muscular.
5. To gain insight into the organization of neurological system and special sense organs.</td></tr>
<tr><td>Module:1</td><td colspan="3">Organization of tissues and organ system</td><td colspan="3">2 hours</td></tr>
<tr><td colspan="7">Anatomical and medical terminology, Structure of the human cell – Four primary tissues, organs and organ systems – Physiology of homeostasis, hormonal control.</td></tr>
<tr><td>Module:2</td><td colspan="3">Cardio Respiratory System</td><td colspan="3">3 hours</td></tr>
<tr><td colspan="7">Structure` of the heart and blood vessels, conducting system of the heart and electrocardiogram, Arterial blood pressure – Factors maintaining blood pressure, Factors regulating blood pressure. Organs of respiratory system – Structure of lungs, Mechanics of breathing, Lung volume and capacities- Regulation of respiration- Hypoxia, Dyspnea.</td></tr>
<tr><td>Module:3</td><td colspan="3">Excretory System</td><td colspan="3">2 hours</td></tr>
<tr><td colspan="7">Structure and function of kidney, Structure of nephron and urine formation, detrusor muscles.</td></tr>
<tr><td>Module:4</td><td colspan="3">Skeletal Muscular System</td><td colspan="3">3 hours</td></tr>
<tr><td colspan="7">Osteology – bones and joints; Myology - smooth, cardiac, skeletal muscles; Structure, function and organization of Joints and other soft tissues.</td></tr>
<tr><td>Module:5</td><td colspan="3">Neurological Systems and Special Sense Organs</td><td colspan="3">4 hours</td></tr>
<tr><td colspan="7">Structure of neuron and organization of brain, Generation of EEG, EMG, ENG, VAG. Ascending and descending pathways. Spatial and temporal summations, reflexes, Special sense organs – visual, auditory and tactile.</td></tr>
<tr><td>Module:6</td><td colspan="3">Contemporary Issues</td><td colspan="3">1 hour</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td></td><td colspan="3">Total Lecture hours:</td><td colspan="3">15 hours</td></tr>
<tr><td colspan="7">Text Books</td></tr>
<tr><td>1.</td><td colspan="6">Gerard J. Tortora, Bryan Derrickson; Principles of Anatomy and Physiology, 2023, 16th edition. Wiley, USA.</td></tr>
<tr><td>2.</td><td colspan="6">Anne Waugh, Allison Grant; Ross and Wilson Anatomy and Physiology in Health and Illness, 2014, 12th edition, Churchill Livingstone, London.</td></tr>
<tr><td colspan="7">Reference Books</td></tr>
<tr><td>1.</td><td colspan="6">Richard S. Snell; Clinical Anatomy by Regions, 2024, 11th edition, Lippincott Williams & Wilkins, Philadelphia, USA.</td></tr>
<tr><td>2.</td><td colspan="6">John E. Hall, Michael E. Hall; Guyton and Hall Textbook of Medical Physiology, 2020, 14th edition, Elsevier, USA.</td></tr>
<tr><td colspan="7">Mode of Evaluation: Quiz, Assignment, Project, Case Study, Seminar, CAT and FAT</td></tr>
<tr><td colspan="2">Recommended by Board of Studies</td><td colspan="5"></td></tr>
<tr><td colspan="2">Approved by Academic Council</td><td>No.</td><td colspan="2">Date</td><td colspan="2"></td></tr>
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Course Code	Course Title	L	T	P	C
XXXXXXXX	Basic Electronics and Measurements	1	0	0	1
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To describe the basic concepts of electronic devices, op-amps and analysis of DC and AC circuits using laws and theorems.
2. To elucidate the concepts of logic Circuits, memory types and illustrates the architecture and interfacing of 8051 microcontroller.
3. To teach the students about the representation of signals, Continuous and discrete time Fourier transform and introduce the different types of sensors and transducers.

Course Outcome

1. Analyze electric circuits using circuit laws, theorems and to comprehend the characteristics of devices.
2. Apply the logic concepts to digital circuits, memory types and comprehend the architecture, instruction sets and programming related to 8051 microcontroller.
3. Assimilate the properties of discrete and continuous time Fourier transforms.
4. Apply the basics acquired from the types of sensors and transducers to design applications.

Module:1	Semiconductor Devices and Integrated Circuits	4 hours

PN Junctions- Formation of Junction- Physical operation of diode, Contact potential and Space Charge phenomena, I - V Characteristics, Zener diode - Introduction to BJT,

FET, MOSFET, amplifiers based on BJT and FET - Ohm's Law - KCL, KVL, Node Voltage Analysis, Mesh Current**,** Op-Amp Fundamentals, Practical Limitations of op-amps, Frequency compensation and stability, Gain bandwidth product, Voltage Follower, Introduction to Instrumentation amplifier.

Module:2	Digital Systems	2 hours

Basic Logic Circuit Concepts- Representation of Numerical Data in Binary Form - Combinatorial and Sequential Logic Circuits - Synthesis of Logic Circuits - Computer

Organization – Memory Types.

Module:3	8051 Microcontroller	2 hours

Introduction to 8051 microcontroller and it's architecture - Memory organization - Instruction sets and assembly language programming - Programming timers – interrupts -

I/O ports and serial port - I/O interfacing.

Module:4	Signals and Systems	2 hours

Continuous-time and Discrete-time Signals: Representation of signals, Signal classification, Types of signals - Operations on signals - Scaling, Shifting, Transformation of independent variables, Sampling LTI Systems - Continuous-Time and Discrete-Time Fourier transforms - Properties.

Module:5	Sensors & Transducers	4 hours

Resistive sensors- Potentiometers, Strain gages, Pressure resistive temperature detectors (RTD), Thermistors, Magneto resistors, Light dependent resistor (LDR). Capacitive sensors- Variable capacitor, Differential capacitor. Inductive sensors - Variable reluctance

sensors, Eddy current sensors, Linear variable differential transformers (LVDT), Variable transformers, Magneto- elastic and Magnetostrictive sensors. Transducers - Electric –Classification, basic

requirements of bio transducers, Factors influencing the choice of the transducer in measuring the Physiological Parameters- Electrodes for ECG, EEG, EMG, EOG.		
Module:6	**Contemporary Issues**	**1 hours**
	Total Lecture hours	**15 Hours**

Text Book(s)

1.	Adel S. Sedra, Kenneth C. Smith and Arun N. Chandorkar, Microelectronic Circuits: Theory andApplications, 2017, 7th Edition, Oxford University Press, New York.
2.	E.W Golding, F.C Widdis, "Electrical Measurements and Measuring Instruments", 2011, 1st edition, Reem Publications Pvt. Ltd, NewDelhi.

Reference Books

1.	Allan V. Oppenheim, S.Wilsky and S.H.Nawab, "Signals and Systems", 2015, 2nd edition, Pearson Education India, Bengaluru.
2.	J. D. Roy Choudhury, Linear Integrated Circuits, 2021, 6th Edition, New-Age International Publishers, New Delhi.
3.	William L Fletcher, "Engineering Approach to Digital Design", 2015, 1st edition, Pearson Education India, Bengaluru.
4.	Muhammad Ali Mazidi, Janice Giillispie Mazidi, "8051 Microcontroller and Embedded Systems", 2014, 2nd edition, Pearson New International Edition, Essex.
5.	Jacob Millman, Christos C Halkias and Satyabrata Jit, "Electronic devices and circuits", 2015, 2nd edition, Tata Mc Graw Hill, NewDelhi.
6.	John. G. Webster and Halit Eren, "Measurements, Instrumentation and Sensors Handbook: spatial, mechanical, thermal and radiation measurements", 2014, 2nd edition, CRC Press,Florida.

Mode of Evaluation: CAT,Digital Assignment, Quiz, FAT

Recommended by Board of Studies			
Approved by Academic Council		Date	